

Current-Voltage Responses of Sugar-Air Cells with Ag Fuel Electrode in Alkaline Aqueous Solution

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Introduction – Electrocatalytic oxidation of sugar (glucose) at an Ag electrode in alkaline aqueous solution has been investigated so as to use this electrode as a fuel electrode for ‘Sugar-Air cells.’ Glucose, $C_6H_{12}O_6$, has 24 electrons per a molecule and provides a higher electrical capacity of 3570 mAh/g, compared with that for two electrons and 824 mAh/g of zinc. Glucose is used as an energy source in human bodies through a smart metabolic loop and is generated by plants through a sophisticated photosynthesis loop. However, there is no efficient means oxidizing sugar to CO_2 and H_2O without over 10 kinds of enzymes. In addition, there is no way to take the 24 electrons out of sugar to external electronics circuits.

Burke et.al. reported an electrocatalytic behavior of noble metals including Pt, Ag or Cu [1], [2], where they pointed out the potential role of incipient hydrous oxide/adatom active sites of sub-monolayer for the electro-oxidation of formaldehyde or glyoxylic acid. The active sites are considered to form much more negative or cathodic potential than the redox potential of these metals. At Ag electrode in alkaline aqueous solution, formation of Ag_2O monolayer was confirmed by Chen et. al. using EQCM. [3] If this Ag_2O monolayer works active for electro-oxidation of glucose, one can expect to have a sugar-air cell having a practical output voltage by combining Ag electrode with the air electrodes which are used in conventional Zinc-Air cells.

Experimental – Current-voltage responses of a cell having a fuel electrode of Ag (1 cm^2) is examined. The cell is equipped with a Pt gauze counter electrode, a Hg/HgO reference electrode, a 0.62% KOH alkaline aqueous solution dissolving 0 to 0.05M glucose, and an air electrode. The air electrode is a PTFE-bonded active carbon with $MnOx$ catalyst embedded in a Ni screen current collector and has a PTFE hydrophobic gas permeable layer on the air side. Cyclic voltammograms are measured to understand the details of sugar oxidation at Ag electrode.

Results and Discussion – The current-voltage curves of the Ag/Air cell with or without glucose are given in Fig. 1. A current output of around $50\text{ }\mu\text{A}/\text{cm}^2$ is obtained at an operating voltage of 0.2 V. Two anodic peaks of I_{a1} and I_{a2} and a cathode peak of I_c appeared in

the cyclic voltammograms (Fig. 2). Up to 0.01 M of glucose, I_{a1} increases and I_c decreases proportionally to the glucose concentration, while I_{a1} reaches a higher and I_c reaches a lower saturated value, when the glucose concentration became more than 0.01 M. I_{a2} was kept almost a constant value. I_{a1} appeared around the potential where the Ag_2O monolayer forms. The present anomalous behavior of I_{a1} and I_c can be explained, if we assume that Ag_2O monolayer oxidizes glucose and returns back to Ag. By HPLC analysis, glycolic acid, formic acid, and oxalic acid were detected as electro-oxidation products.

References

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Fig. 1 Current-voltage responses of the sugar/air cell with an Ag working electrode

Fig. 2 Cyclic voltammograms of Ag electrode in a 0.62% KOH aqueous solution containing 0 to 0.05M glucose.

